



"Integrated" Agriculture as a Base for High Density Renewable Fuels in Hawai`i

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### Hawai'i BioEnergy:

A Coalition to Support the Economic, Environmental and Community Integrity of Hawai'i through Improved Energy Security and Contributions to a Green Economy



Maui Land and Pineapple, Inc.



Khosla Ventures

khosla ventures

Ohana Holdings

**Ohana Holdings** 

**Finistere Partners** 



Kamehameha Schools



**Grove Farm** 



"Local Business, Local Growth, Local Self-Sufficiency"



### Renewable Energy: Constructing the Value Chain Forming alliances is key to economic productivity

#### Hawai'i Energy and Food Challenges

- ☐ Relatively small and isolated parcels of land present logistical and scale challenges
- ☐ Align form of energy with local demand
  - ☐ 450 million gallons gasoline (45 million gallons ethanol)
  - ☐ 600 million gallons jet, diesel and other high density distillates (transportation, power)
- ☐ Fill gaps in the local agricultural value chain
  - >animal feed to support local meat and milk production

#### **Corporate Value Chain**

Land, Diversified Ag, Biomass Transformation Distribution to Market

- Sustainable practices
- Diversified crops
- Efficient water management
- Increased land productivity
- "Recycle" waste streams
- Global best practices
- Food and Fuel

- Proper alliances
- Fuel that utilizes existing infrastructure
- Department of Defense
- Electric Utilities
- Transportation









### Increased Land Productivity through Innovation and Integration ("per acre back of the envelop estimates")

| Current   | Current  |
|---|--|
| Sugar Focus   | Energy Focus   |
| <ul><li>7-8 tons sugar</li><li>5000 kwh power</li><li>1 unit CO<sub>2</sub></li></ul> | <ul> <li>1025 gallons<br/>ethanol</li> <li>5500 kwh power</li> <li>1.5 units CO<sub>2</sub></li> </ul> |





# New Crop Cultivars: Changing Goals Allows us to Change Tools Energy Cane vs Conventional Cane

•Energy Cane data courtesy of Fernando Reinach, Canavialis – Brazil

Photos courtesy of CERES and Texas A&M University

| Fraction | Conventional Sugarcane tons/acre (DW) | Energy Cane tons/acre* (DW) |
|----------|---------------------------------------|-----------------------------|
| Sucrose  | 7.5                                   | 9.4                         |
| Fiber    | 7.5                                   | 17.0                        |
| Total    | 15.0                                  | 26.4                        |



- ➤ new hybrid Sorghum varieties (eg. CERES Thousand Oaks, CA and Texas A&M, College Station, Texas)
- ➤ Sorghum uses 30% less water per ton of biomass produced than sugarcane



## Consolidating Technology Improves Economics of EtOH production from Sugarcane

... and remarkably increases land productivity "Back of the Envelope" Calculations

- 25 million gallon target
- Assume initial ~50 tons cane/acre
- EtOH and power only facility
- Energy cane or new Hybrid Sweet Sorghum varieties
- Advanced Processing

| Case                           | EtOH<br>(gal/acre) | Land<br>Required<br>(acres) | Fiber (tons/acre) |
|--------------------------------|--------------------|-----------------------------|-------------------|
| Base                           | 1025               | 24,500                      | 7.5               |
| Hi-Fiber                       | 1290               | 19,200                      | 17.0              |
| HF +<br>Advanced<br>Processing | 2500*              | 10,000                      |                   |

<sup>\*</sup> Not all fiber to sugar, some retained for power production



## Consolidating Technology Improves Economics of High Density Fuel production from Sugarcane

... and remarkably increases land productivity "Back of the Envelope" Calculations

- 25 million gallon target
- Assume initial ~50 tons cane/acre
- Fuel and power only facility
- Energy cane varieties
- Advanced Processing

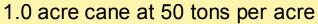
| Case                     | High Density Fuels (gal/acre) | Land<br>Required<br>(acres) | Fiber<br>(tons/acre) |
|--------------------------|-------------------------------|-----------------------------|----------------------|
| Base                     | 625                           | 24,500                      | 7.5                  |
| Hi-Fiber                 | 790                           | 19,200                      | 17.0                 |
| HF + Advanced Processing | 1700*                         | 10,000                      |                      |

<sup>\*</sup> Not all fiber to fuel, some retained for power production



"Refocusing" Agriculture: The base for a sustainable, economic and secure Hawai`i ("back-of-the-envelope" estimates)



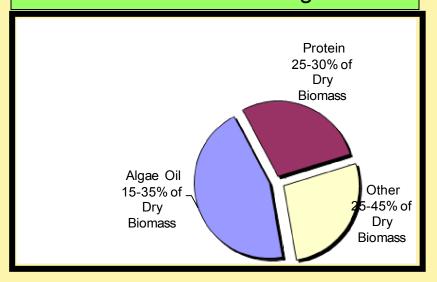


- 625 gallons renewable diesel
- 5500 kwh of power

50 tons of cane/acre produces 15.2 tons CO2/acre on processing



#### One metric ton of algae



#### 15.2 tons CO2 produces 5 tons of algae

- 5 tons of algae/acre
  - 300 650 gallons of oil
  - 1.3 tons of protein
  - 1.3 tons of biomass (=4.3 tons whole cane = 573 kwh of power
- Algae ponds ~10% of land available for cane or sorghum



### Increased Land Productivity through Innovation and Integration ("per acre back of the envelop estimates")

| Current<br>Sugar Focus   | Current<br>Energy Focus  | Future Energy Focus with advanced varieties and advanced processing   | Future Energy Focus with advanced varieties and advanced processing integrated with algae  |
|--|--|---|--|
| <ul> <li>7-8 tons sugar</li> <li>5000 kwh power</li> <li>1unit CO<sub>2</sub></li> </ul> | <ul> <li>1025 gallons ethanol</li> <li>5500 kwh power</li> <li>1.5 units CO<sub>2</sub></li> </ul> | <ul> <li>~1700 gallons of high density fuel</li> <li>5500 kwh power</li> <li>2.5 units of CO<sub>2</sub></li> </ul> | <ul> <li>~1700 gallons of high density fuel</li> <li>5500 kwh power</li> <li>650 gallons oil</li> <li>1.5+ tons protein</li> </ul> |



## Agriculture can Contribute to Energy and Food Security in Hawai`i

- ➤ Land base is fragmented but we have remarkably productive soils and climate
- ➤ Integration of technical innovations and aligned partnerships across the value chain can support significant volumes of fuel and animal feed production



- Sustainable practices
- Diversified Crops
- Efficient water management
- Increased productivity
- "Recycle" waste streams
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- Proper alliances
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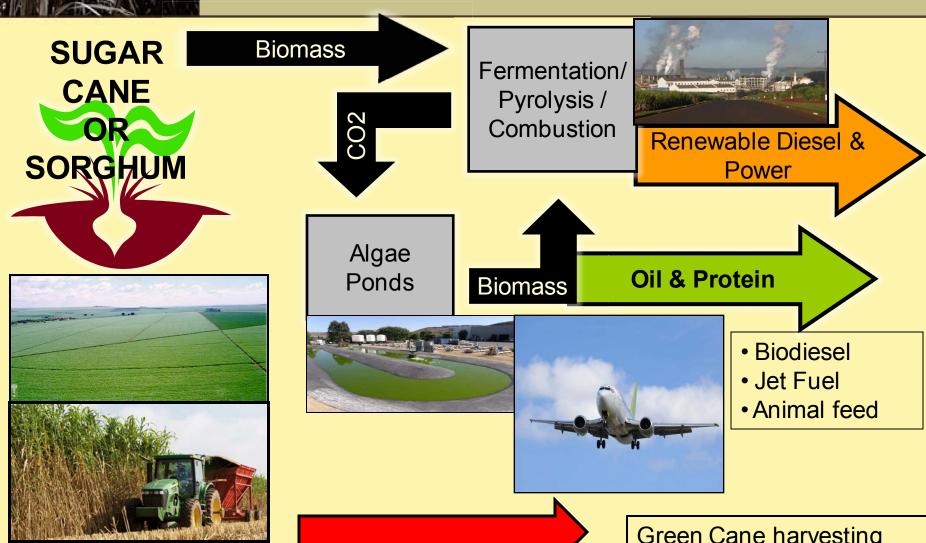








### Integrated Biorefinery



Green Cane harvesting produces up to 30% more usable biomass